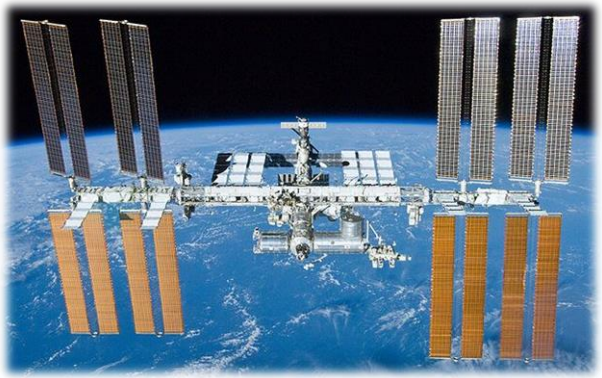
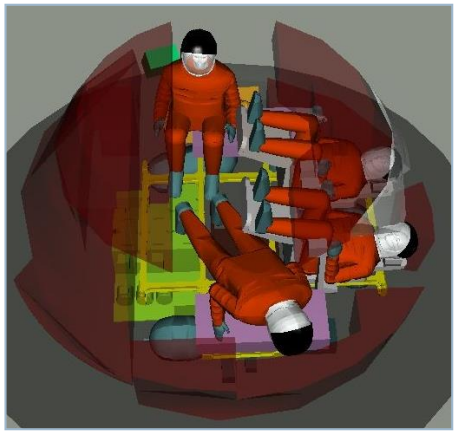


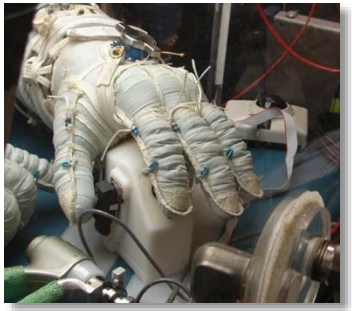
Human Systems Integration at NASA: From Research to Implementation

Mihriban Whitmore, Ph.D.
Lead Scientist, Human Factors and Behavioral Performance
Human Research Program
NASA Johnson Space Center

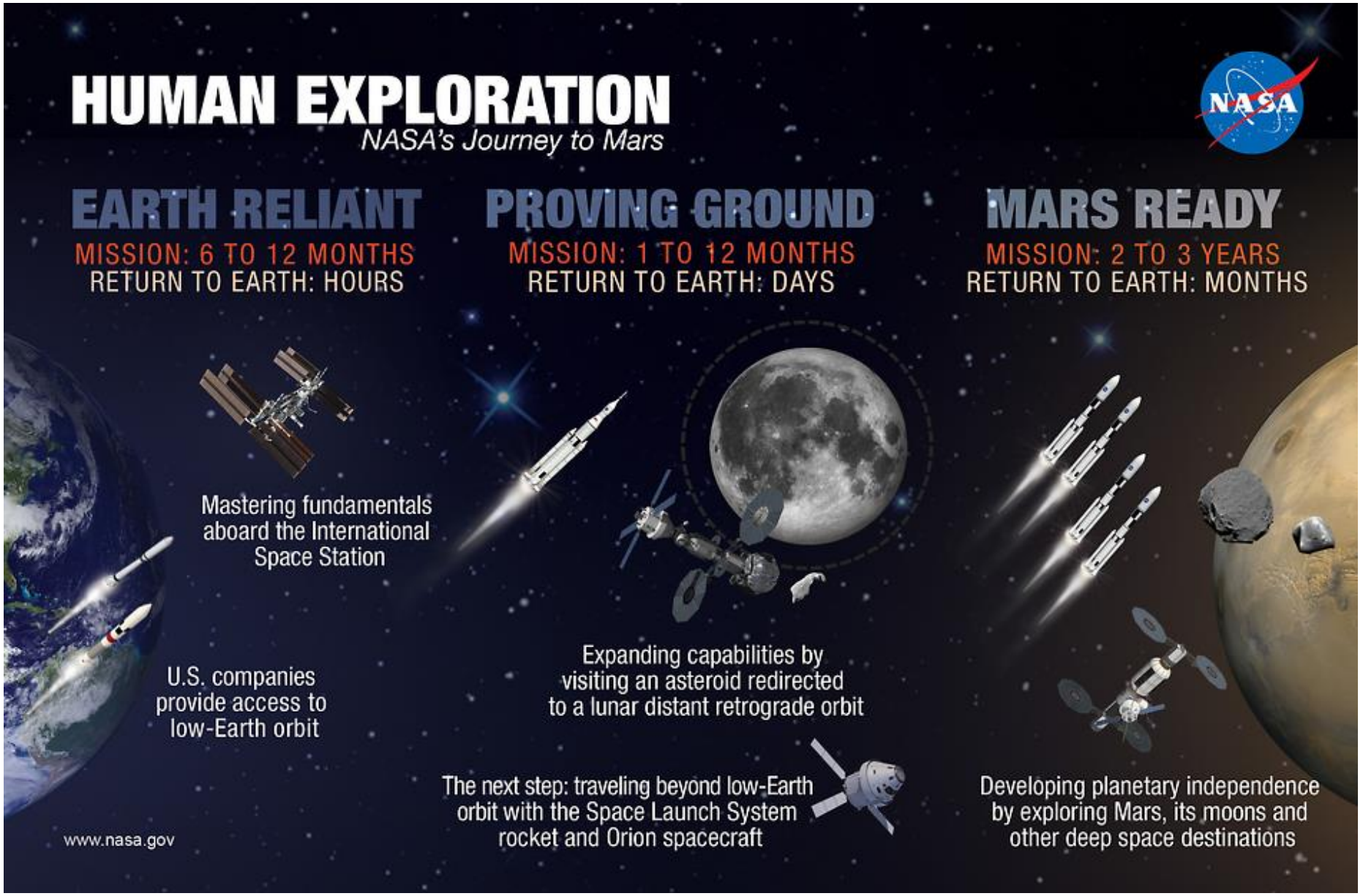
Human Systems Integration at NASA

- HSI-related Research
  - Human Research Program
- HSI Implementation
  - HSI Heritage and where HSI stands today
- Forward Work

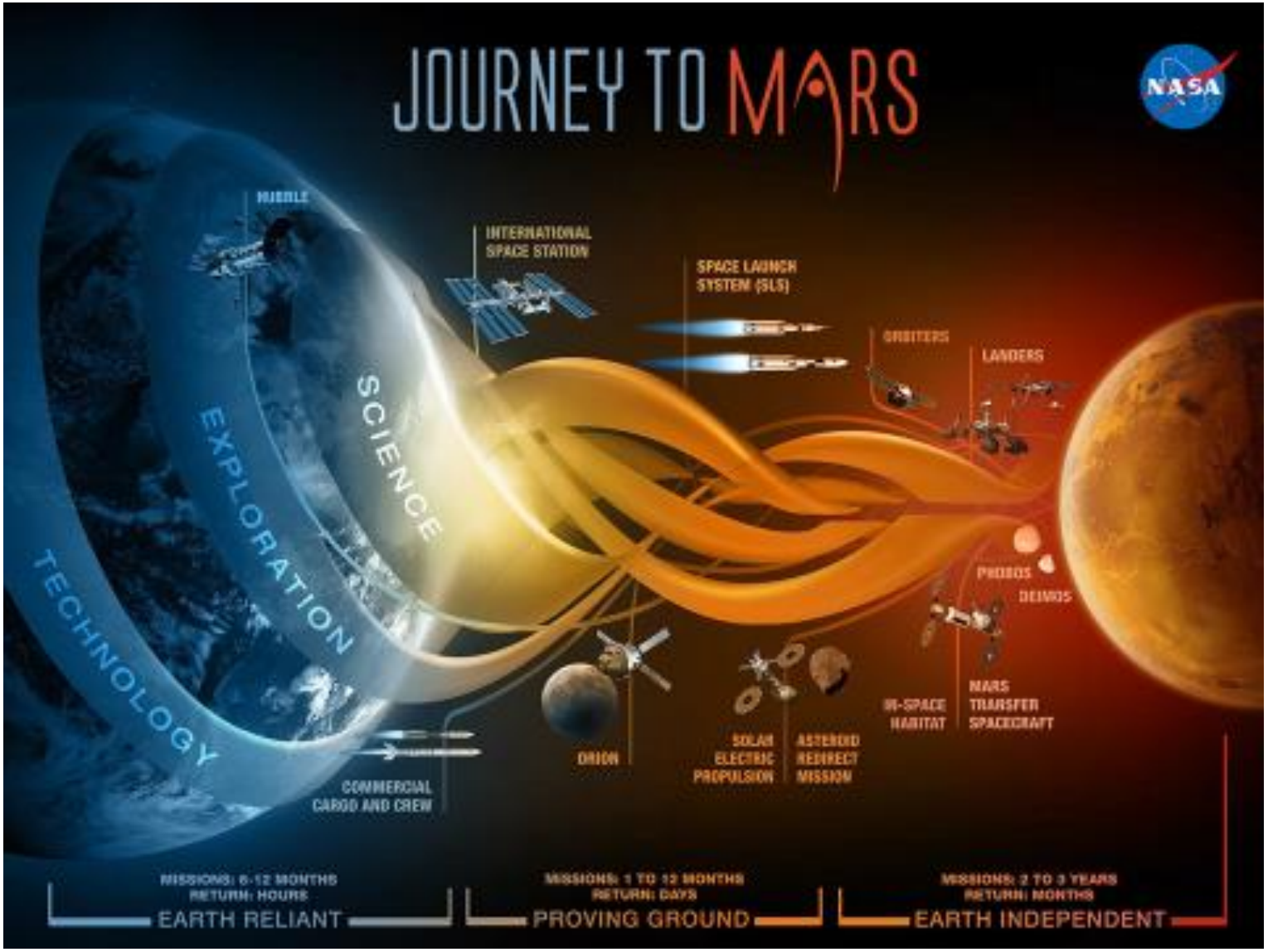




Destination Mars



Destination Mars



HSI-related Research – Human Research Program

Human Research Program (HRP)

Mission: To enable space exploration beyond low Earth orbit by reducing the risks to human health & performance through a focused program of:

- Basic, applied, and operational research

(http://humanresearchroadmap.nasa.gov/explore/)

Primary Hazards to HRP Risks

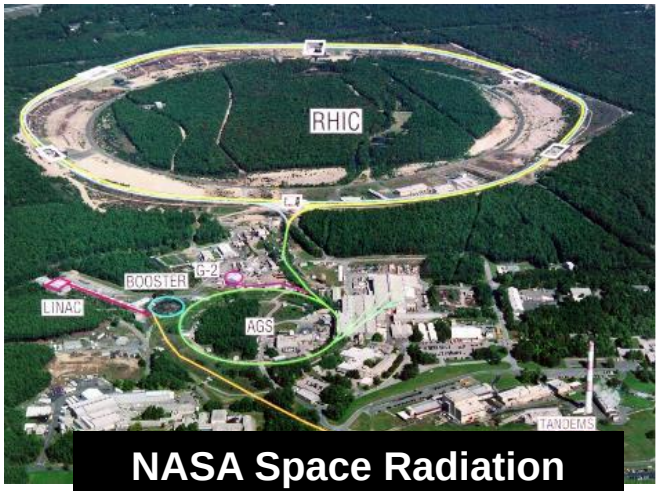
- Decreased gravity
- Isolation and confinement
- Hostile/ closed environment
- Increased radiation
- Distance from Earth

Components of HRP

- HRP is composed of six Elements
  - Human Health Countermeasures
    - *Physiology*
  - Behavioral Health and Performance
    - *Individual and interpersonal*
  - Space Human Factors and Habitability
    - *Interfaces between humans and vehicles/habitats*
  - Exploration Medical Capability
    - *Medical care for missions*
  - Space Radiation
    - *Radiation exposure and biological effects*
  - ISS Medical Project
    - *Infrastructure for flight experiments*

- HRP funds the National Space Biomedical Research Institute (NSBRI) through a cooperative agreement to pursue research that complements the HRP portfolio

Venues for Conducting Research



NASA Space Radiation Lab

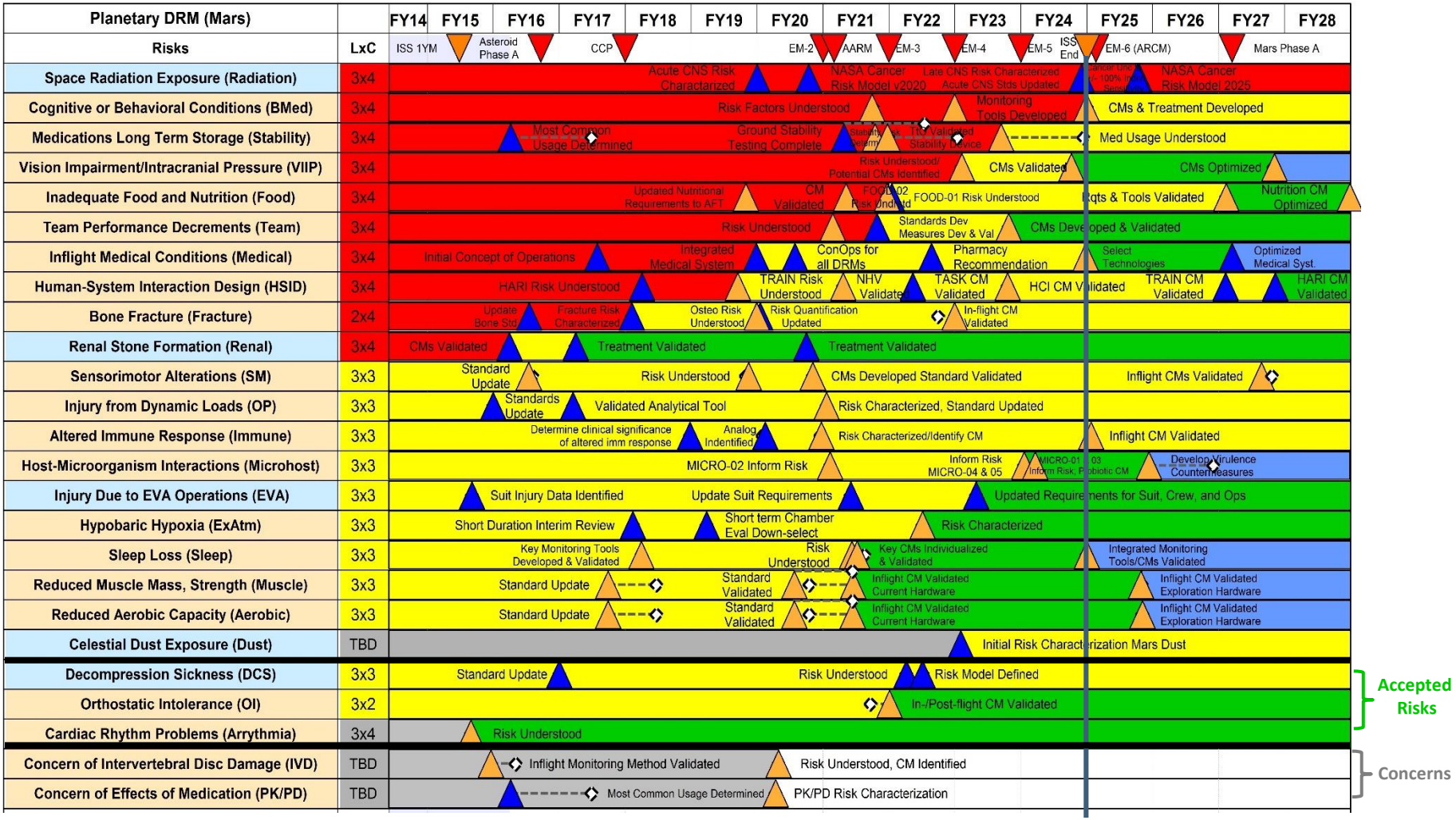
Human Exploration Research Analog

Risk Mitigation

1. Determine Relevant Risks
   - 33 risks and risk factors relevant to exploration within HRP research portfolio
   - Focused on risks that could have a substantial negative effect on an exploration mission
2. Identify gaps in
   - knowledge
   - mitigation capability
3. Identify the research products required to fill the gaps
4. Generate research products
5. Validate research products (as needed)
6. Reassess gaps in a) knowledge or b) mitigation capability and return to step 3 as needed

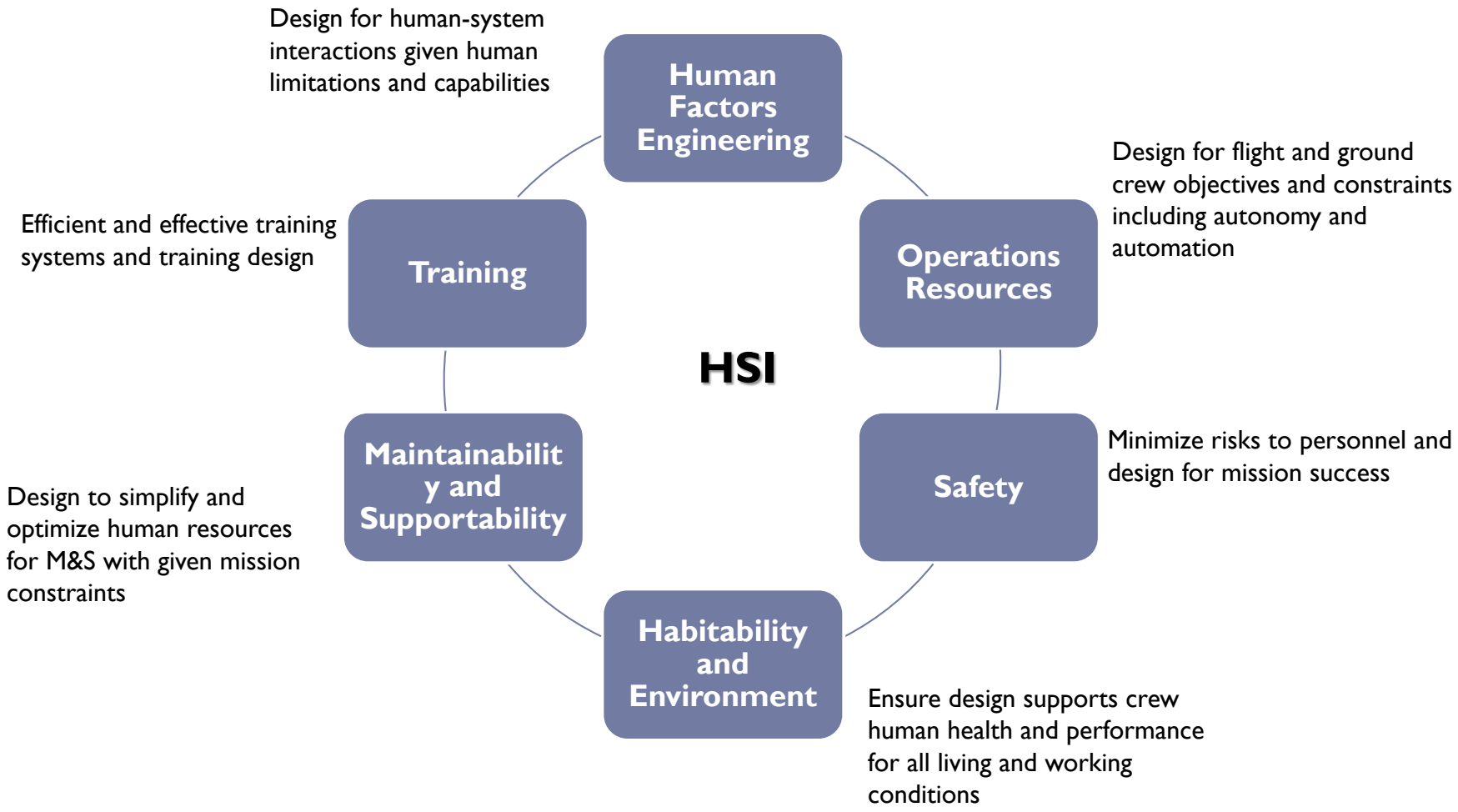
Evidence → Risks → Gaps → Tasks → Deliverables

HRP Integrated Path to Risk Reduction



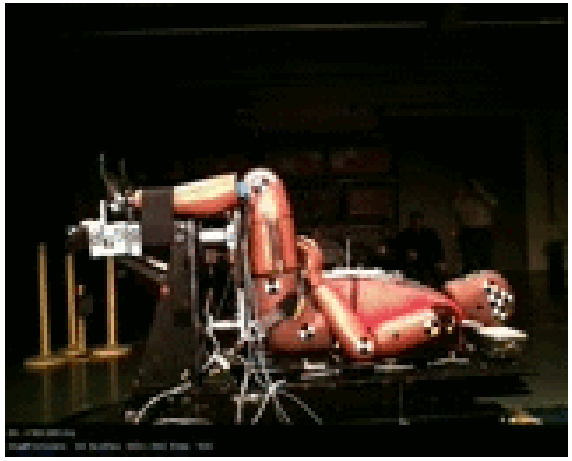
HSI Implementation – HSI Heritage and Where HSI stands today

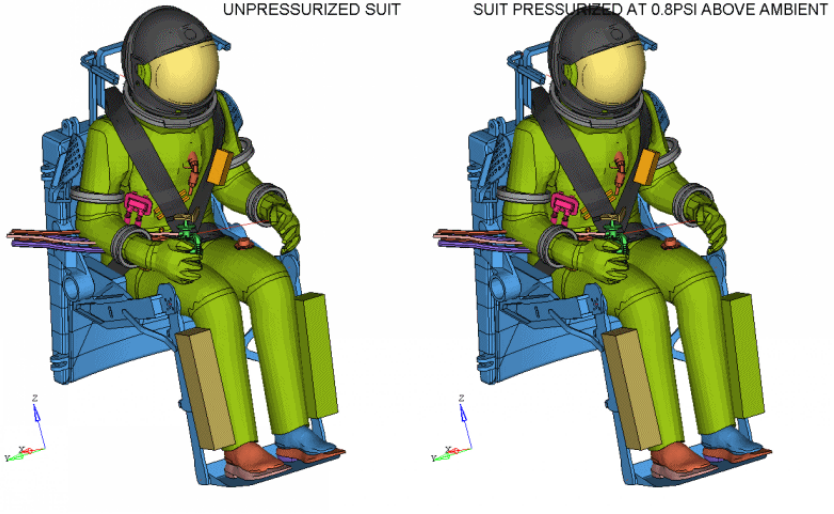
NASA HSI Domains



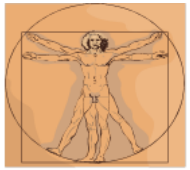
Where HSI Stands Today

- The JSC HSI Employee Resource Group has been active for over 4 years
- HSI practice has been inserted into the Agency NPR 8705.2B, the new revision of the Systems Engineering Handbook, and also the Program Management Handbook (7123.1B)
- The HSI Practitioner's Guide has been completed and released (NASA/SP-2015-3709)
- We have been actively engaged in numerous HSI Communities:
  - Multi-Center NASA HSI Steering Committee
  - Agency-wide Human Factors Engineering (HFE) Capability Leadership Team
  - National Defense Industry Association committee on HSI Metrics & Advocacy
  - Naval Post Graduate School HSI Curriculum Review
  - Department of Defense Joint HSI Working Group and Community of Interest





HSI "Document Tree"



NASA Experience

NPR 7123.1B

NASA Systems Engineering Processes and Requirements

April 18, 2013

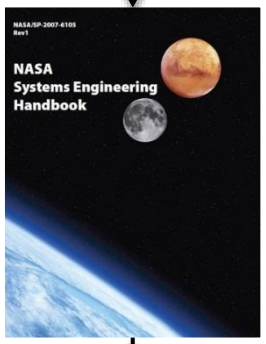
National Aeronautics and Space Administration

Revision B issued 2013 incorporated HSI

SP-2014-3705

Program and Project Manager's Handbook

National Aeronautics and Space Administration



Major update drafted in 2014 with HSI content

The NASA SE Handbook is available as two products (new to 2016)

- NASA Expanded Guidance on Systems Engineering (NEN; electronic),
- NASA Systems Engineering Handbook ('core' document; paper and electronic), NASA/SP-2016-6105

SP-2015-3709

Human Systems Integration (HSI) Practitioner's Guide (HPG)

National Aeronautics and Space Administration

Humans Systems Integration (HSI) Practitioner's Guide (Baseline Nov 2015)

- Supports HSI implementation consistent with the NASA SE model
- Handbook style HSI best practices and practical information

Other Key References:

NASA-STD-3001 Space Flight Human-System Standard Vol 1 (Crew Health) and Vol 2 (Human Factors, Habitability & Environmental Health)

NASA/SP-2010-3407 Human Integration Design Handbook (HIDH)

The HSI Practitioner's Guide

- Purpose: Provide guidance as to how to incorporate HSI into the existing NASA Systems Engineering (SE) processes and methodology
- Content of HSI Practitioner's Guide (SP-2015-3709)
  - Best practices and guidance for conducting HSI
  - Written for practitioner but has guidance for managers and disciplines
  - Phase-by-Phase guidance for activities and products, per NASA SE models, goes further and deeper than the SEHB
  - Skills-based tutorials and guidance for scaling for any size program/project
  - Checklists and annotated HSI Plan outline
- What background is the user expected to have?
  - It is expected is that the HSI lead/practitioner has come from a system engineering or human systems background and already has a good knowledge and experience with the SE HB.

Scaling HSI

- Recent agency emphasis has been on small-scope and/or advanced technology development projects
  - This offers an opportunity for early inclusion in pre-phase A activities (i.e., early conceptual design)
- Systems engineering (SE) and HSI activities may be tailored to a level appropriate for the degree/size/scope/development phase of the project
- The HSI Practitioner's Guide provides guidance for scaling HSI (summarized below)

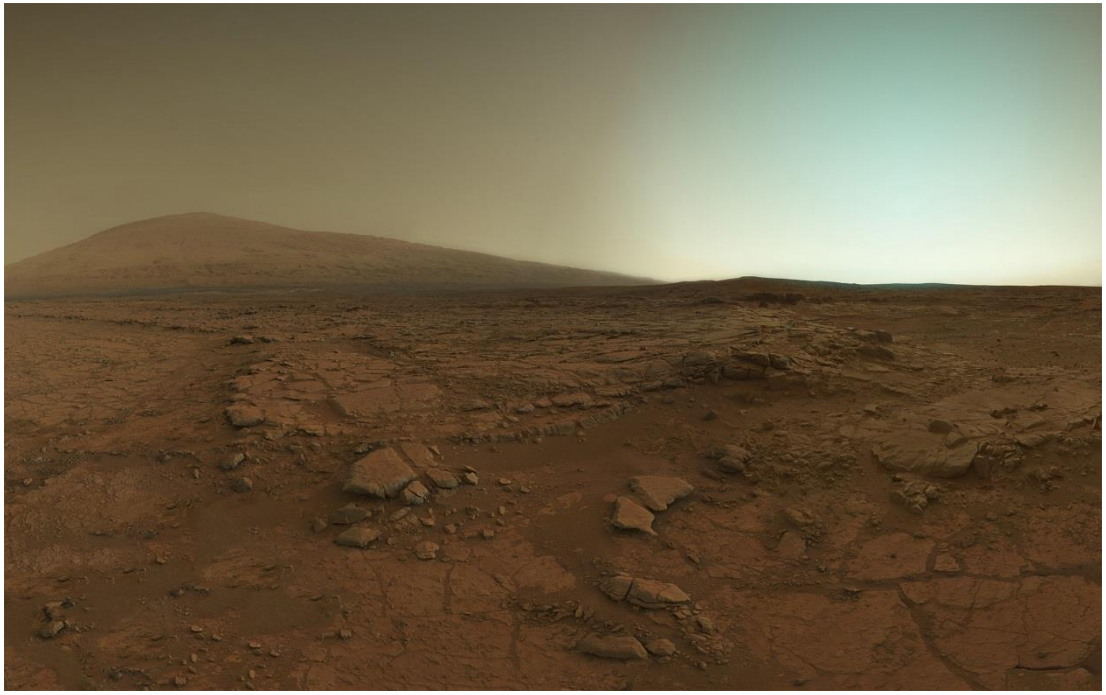
HSI Product	Large-Scale HSI Effort	Medium-Scale HSI Effort	Small-Scale HSI Effort
ConOps	Standalone Doc(s)	Possible Standalone Doc	Part of Project Docs
HSI Plan	Standalone Doc	Part of SEMP	Part of Project Docs
HSI Team	Required (Human Rated)	Recommended	As needed
Human in the loop	Significant Effort	Strong Effort	Modest Effort
Human-centered Design	Significant Effort	Strong Effort	Modest Effort

Forward Work

What is next?

- Next steps for HSI Implementation – From review of lessons learned in the DoD, NASA, and other environments, the following are key components we plan to implement HSI within systems engineering lifecycle processes
  - HSI Plan
  - HSI Team
  - Use of Metrics to track progress
- HSI Training Program for Program and Project managers, as well as HSI integrators and practitioners
- Governance Model
- HSI in Agile Development Process

Thank You!



Mihriban Whitmore
Mihriban.whitmore-1@nasa.gov

Supplementary Charts

Component 1: HSI Plan

- The HSI plan is a "living" document that highlights the methods by which the program or project will ensure HSI is a core part of the lifecycle
  - **Goals** and **deliverables** for each phase of the lifecycle are defined
  - **Entry** and **exit criteria** with defined metrics are listed for each phase, review, and milestone
  - Roles and responsibilities are defined
  - Methods, tools, requirements, processes and standards are identified
  - Includes HSI issues, risks, and mitigation plans
- The HSI Plan can be a part of the Program/Project SEMP, a standalone document, or part of other project documentation depending on the HSI effort required
  - The plan is typically **updated** after successful completion of each phase to ensure relevance is maintained and as new issues arise
  - An HSI Plan template is published in the HSI Practitioner's Guide (NASA/SP-2015-3709), Appendix A

Component 2: HSI Team

- An HSI Team is typically composed stakeholders and domain experts relevant to the program or project, as well as lead HSI practitioners
- An HSI Team should be created before the program or project is initiated to help formulate the HSI Plan, but is required to be stood up by SRR per NPR 8705.2B
  - An HSI Team is almost always needed once the program or project starts in order to ensure the HSI Plan is implemented, facilitate resolution of HSI related issues during the lifecycle, identify human related cost drivers which increase life cycle costs or decrease system performance, and guide solutions
- HSI Team Responsibilities:
  - Identify, resolve, and track HSI related issues as the program progresses
  - Generate/Review relevant system documents for major design reviews
  - Track entry and exit criteria for each lifecycle phase, review, and milestone
  - Ensure the most effective, efficient, and affordable design possible through tradeoff studies within and between domains, disciplines, and/or systems
  - Update the HSI Plan as the program or project proceeds through the SE lifecycle
  - Ensure Test and Evaluation (T&E) efforts are sufficient to verify/validate HSI requirements

Component 3: Metrics

- Without HSI metrics it is difficult to assess HSI success and progress
- Metrics should include well defined entry and exit criteria for each phase, review, and milestone of the lifecycle.
- Example metrics may include:
  - Using checklists to track consideration of key HSI related requirements
  - Crew time or efficiency measures for task completion
  - Training time estimates
  - Ensuring consideration of HSI has been included in relevant portions of formal plans, tests, and evaluations
  - Integration of constraints and requirements for logistics support, program resources and training plans
  - Conduction of inter-HSI domain trade-offs and identification of interactions with other major systems and subsystems
  - Formulation of plans to perform HSI review/assessments on hardware/software revisions that add/delete/defer capability not addressed in the capability documents